* NOTICES *

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The sectional view of the ferromagnetic tunnel magneto-resistive effect film by the conventional technique.
[Drawing 2] The property Fig. showing the relative magnetization include angle of the fixed bed and a free layer, and the asymmetric relation of a regenerative signal.
[Drawing 3] The sectional view of the first example of the magneto-resistive effect mold component by this invention.
[Drawing 4] The sectional view of the second example of the magneto-resistive effect mold component by this invention.
[Drawing 5] The perspective view of the first example of the magneto-resistive effect mold head by this invention.
[Drawing 6] The perspective view showing the thin film magnetic head equipped with the magneto-resistive effect mold head by this invention, and a magnetic disk.
[Drawing 7] The perspective view of the second example of the magneto-resistive effect mold head by this invention.
[Drawing 8] The explanatory view showing the configuration of the magnetic recorder and reproducing device which carried the magneto-resistive effect mold head by this invention.
[Description of Notations]
11 13 [-- Lower electrode,] -- A ferromagnetic, 12 -- An insulator, 14 -- The antiferromagnetic substance, 21 22, 38, 43 -- 23 An antiferromagnetic substance layer, 35 -- One magnetic film of the fixed bed, 24 36 -- 25 The middle metal membrane of the fixed bed, 37 -- The magnetic film of another side of the fixed bed, 26 -- A middle insulator layer, 27, 33, 48 -- An insulator layer, 28, 32, 49 -- Permanent magnet film, 29 -- An up electrode layer, 30 -- 34 The free layer ferromagnetic film, 45 -- Middle insulating layer, 40, 50, 61 -- A free layer, 41 -- Lower shielding, 42 -- Lower metal gap film, 44 [-- Magnetic disk,] -- The fixed bed, 46 -- An up metal gap layer, 47 -- Up shielding, 51 52 [-- A digital disposal circuit, 56 / -- The record magnetization on a medium, 57 / -- The magnetic pole of a recording head 58 / -- An exiting coil, 59 / -- A magneto-resistive effect mold head, 62 / -- Antiferromagnetism film.] -- A spindle motor, 53 -- A slider, 54 -- An actuator, 55

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the magnetic recorder and reproducing devi which carried a magnetoresistance-effect type element and this.
[0002]
[Description of the Prior Art] high sensitivity electromagnetism -- the so-called ferromagnetic tunnel junction elemen which has the three-tiered structure of a ferromagnetic metal / insulator / ferromagnetic metal as shown in drawing 1 a sensing element attracts attention In order to make the magnetoresistance effect discover by this three-tiered structu magnetization of the first ferromagnetic metal and magnetization of the second ferromagnetic metal need to answer independently substantially to an external magnetic field. Specifically, while one magnetization is answering and moving to the external magnetic field, as for another side, it is desirable to stand it still substantially.
[0003] By contacting one ferromagnetic 13 to the antiferromagnetic substance 14 which consists of a Cr system alloy by considering as the composition of four layers of parenchyma of ferromagnetic 11 / insulator 12 / ferromagnetic 13 antiferromagnetic substance 14 on a substrate 10 like [JP,4-103014,A] drawing 1 , in order to realize such operating state, the 1 direction anisotropy by the exchange interaction is given, and a means to fix magnetization substantially indicated. Hereafter, the fixed bed and the ferromagnetic layer of another side are called free layer for the ferromagnetic layer in contact with the antiferromagnetic substance.
[0004] When using a magnetoresistance-effect type element as the reproducing head by digital magnetic recorder an reproducing device like a magnetic disk unit, there are some troubles which were not in the element of an induction type. Among those, one of the biggest things is called vertical asymmetry of a regenerative signal. In digital recordin corresponding to the bit of the signal to record, the 2-way with which a medium magnetic film disagrees is magnetiz and a positive and negative magnetic field is impressed to the reproducing head from a magnetic reversal field, i.e., t field where south pole N poles face each other. an induction-type element -- like -- perfect -- linear electromagnetism when it has a response characteristic, the reproduction output corresponding to the amphipathy of a magnetic field should completely become the same
[0005] However, generally nonlinearity arises under the influence of the magnetic saturation of a soft-magnetism film etc., and a reproduction output becomes a different size to a positive and negative signal magnetic field. The followin amounts are used for generally expressing this asymmetric degree.
[0006]
[Equation 1] Asym=(V+-V-)/(V++V-
However, V+ and V- mean the output corresponding to positive and the negative medium magnetic field, respectivel It is this Asym at the magnetoresistance-effect type head using the multilayer type magnetoresistance-effect film. Wh is decided is the relative angle of free layer magnetization and fixed-bed magnetization.
[0007] Drawing 2 is Asym to the relative angle of the free layer in operating state, and the fixed bed. Change is show It is Asym=0% when this is seen. In order to carry out, it turns out that free layer magnetization and fixed-bed magnetization need to be making the angle of 90 degrees.
[0008] Since magnetization of the fixed bed is being substantially fixed as mentioned above, it is necessary by the actual element to control only magnetization of a free layer. Now, the balance of the joint magnetic field between the free layer-fixed beds and the static magnetic field produced since patterning of the fixed bed was carried out has determined the magnetization direction of a free layer with the ferromagnetic tunnel magnetoresistance-effect eleme
[0009] Since current is passed in a film surface in a spin bulb magnetoresistance-effect type head with a certain meta interlayer from the former, the direction of free layer magnetization is changed by current strength, and bias is compensated, and it is Asym. Although having lost was possible, in order to pass sense current at right angles to a fil surface in a ferromagnetic tunnel magnetoresistance-effect element, bias is determined only by two persons of point although based also on film composition, to the former being at most about.about ten Oes, depending on the case, the

latter may be changed to a uniform magnetic field and may have the effect of about 50 Oes Therefore, Asym In orde make it as small as possible, it is necessary to reduce the static magnetic field which the fixed bed exerts on a free layer.

[0010] Since the static magnetic field from the fixed bed is generally proportional to magnetization and thickness product of a fixed-bed ferromagnetic, a static magnetic field can be reduced by making thickness thin, using a small material of saturation magnetization. However, since reduction of magnetic-reluctance rate of change is generally caused in any [the] case, these are simply inapplicable.

[0011]

[Problem(s) to be Solved by the Invention] With the conventional ferromagnetic tunnel magnetoresistance-effect typ element, since the static magnetic field from the fixed bed to a free layer was not able to be canceled by the free laye fixed-bed joint magnetic field, the bias profile of a free layer was not optimized but big vertical asymmetry appeared the regenerative signal. In a digital magnetic recorder and reproducing device, possibility that will read and an error will occur becomes high. In order to improve only vertical asymmetry, there is a method of thin-film-izing the fixed bed and reducing the magnetic moment. However, in order to accompany this by reduction of the magnetoresistance effect itself, the magnetoresistance-effect element of high sensitivity is no longer obtained.

[0012]

[Means for Solving the Problem] In order to reduce the vertical asymmetry which appears in a reproduction output, maintaining high sensitivity, by combining the ferromagnetic layer of two sheets with the fixed bed strongly in antiferromagnetism using a cascade screen with three layer structures of a ferromagnetic / non-magnetic metal film / ferromagnetic, fully maintaining the thickness of the ferromagnetic which produces the magnetoresistance effect, it made small the magnetic moment in the whole fixed bed, and has improved the bias profile of a free layer.

[0013]

[Embodiments of the Invention]

Example 1 drawing 3 is the cross section of the magnetoresistance-effect element which applied this invention. On a substrate, lower electrode 21 (TaW;100nm) / antiferromagnetism film 22 (FeMn;30nm) / fixed beds 23 and 24, and t 25 (Co;3 nm/Ru;0.6 nm/Co;3nm) / middle insulating layer 26 (2O3; 1nm of aluminum) / free layer 30 (NiFe5 nm/Co1nm) After forming membranes, portions other than the pattern of the size of a request of only the free layer 3 are removed by the ion milling method. By carrying out the laminating of insulator layer 27 (2O3; 3nm of aluminum the permanent magnet film 28 (CoCrPt;20nm) to the field after removal by the lift-off method, magnetization stabilization of the free layer magnetic film 30 was attained.

[0014] With the magnetoresistance-effect element of this example, the element which shows the big maximum magnetic-reluctance rate of change of 15% was obtained. the exterior -- uniform -- the stable thing in which the resistance change curvilinear ******** transfer curve to magnetic field**30Oe does not have a hysteresis for alignment was observed

[0015] In addition, the same effect was acquired even if it used SiO2, SiC, AlN and Ti 2O3, VO, CrO and Zr 2O3, a NbO, TaO and WS for the middle insulating layer 26. Moreover, even if it considers as the method of carrying out patterning of the free layer 30 and uses the RIE (Reactive Ion Etching) method other than the describing [above] io milling method, it is clear for production of an element which realizes an equivalent property to be possible.

[0016] Example 2 drawing 4 is the cross section of the second example of the magnetoresistance-effect element of th invention. a substrate top -- the lower part -- membranes were formed in order of electrode layer 21 (TaW;100nm) / free layer 40 (NiFe5 nm/CoFe1nm) / middle insulating layer 34 (2O3; 1nm of aluminum) / fixed beds 35 and 36, and the 37 (Co;3 nm/Ru;0.6 nm/Co;3nm) / antiferromagnetism film 38 (CrMnPt;30nm) / up electrode layer 39 (TaW;100nm) Moreover, patterning only of the free layer is carried out like the first example, and the 32/insulator la 33 (2O3; 10nm of aluminum) of magnetization stabilization layers by the CoPt system alloy permanent magnet film formed. At this example, about 12% and high magnetic-reluctance rate of change were obtained at the room temperature.

[0017] In addition, the equivalent effect was acquired, although the antiferromagnetism film shown in the top was CrMnPt (30nm), in addition even if it used MnIr and MnPt. Even if it uses other conductive antiferromagnetism film it is clear that the same effect is acquired.

[0018] Example 3 drawing 5 is the perspective diagram of the magnetoresistance-effect type head equipped with the magnetoresistance-effect element which applied this invention. Although the composition of the magnetoresistance-effect elements 43, 44, 45, 48, 49, and 50 is the same as that of an example 1, on both sides of the metal gap films 42 and 46, the shields 41 and 47 of a soft-magnetism film are constituted by the element upper and lower sides. For eac metal gap thickness, the interval of a vertical shield is 0.1 micrometers. It is decided that it becomes and a free layer becomes in the center of the whole gap. Here, 60nm and the lower gap film 42 were set to 25nm for the up gap film Drawing 6 showed this magnetoresistance-effect type head 59 and the thin film magnetic head equipped with the induction-type write-in he d on the slider 53.

[0019] It recorded by exciting a magnetic pole 57 in a coil 58 by passing the current corresponding to the record sign and making a medium it magnetization 56 first, on the disk 51 which carries out high-speed rotation like drawing 6 . Next, it reproduced by the magnetoresistance-effect type head 59 which applied this invention. It is good and reproducing characteristics are 0.1mA. About 5mV stable reproduction output was obtained with sense current. Neit noises, such as a Barkhausen noise, nor waveform distortion, such as a base-line shift, were also seen. In addition, th vertical asymmetry of a regenerative signal is Asym=1%. It was a grade and was the level which does not become a problem practically.
[0020] Example 4 drawing 7 is the perspective diagram of the magnetoresistance-effect type head equipped with the magnetoresistance-effect element which applied this invention. A different point from an example 5 is a point used a the antiferromagnetism film 62 which carried out patterning so that only the portion which contacts the magnetic for sencor of the center of a free layer instead of a permanent magnet film in a means to stabilize magnetization of a free layer might be removed. Here, NiO (30nm) was used.
[0021] The reproducing characteristics of a head were almost equivalent to the example 3. In addition, instead of NiO even if replaced by CrMnPt (20nm) / aluminum2O3 (50nm) bilayer film, the head with an almost equivalent propert was obtained.
[0022] Example 5 drawing 8 expresses the magnetic disk unit which applied this invention simple. The record mediu which consists of a CoCrPt system alloy film had accumulated on the front face of the metal which carries out high-speed rotation by the spindle motor 52, or the glass disk 51 by the spatter, the thin film magnetic head formed on the chip (slider) 53 of the ceramics which surface in response to the airstream accompanying rotation of a disk was used and the digital signal was recorded and reproduced on the record medium. The thin film magnetic head consists of an induction-type recording head which consists of a magnetic pole of a NiFe system alloy, and a coil of Cu, and the magnetoresistance-effect type reproducing head of example 3 publication.
[0023] Furthermore, the chip of the above-mentioned ceramics is attached in the working arm, and an arm can be substantially moved now to radial with the actuator 54 equipped with the voice coil motor. Therefore, the thin film magnetic head can be mostly accessed all over a disk. Moreover, on a record medium, the servo signal which specifi the truck position other than a record signal is, and a head can be positioned with high precision with a closed loop control by feeding back the servo signal which the reproducing head reproduced to an actuator.
[0024] Moreover, it also has the electrical circuit system 55 which processes a regenerative signal and a servo signal controls a mechanism system. With this equipment, high recording density was able to be attained by using the thin film magnetic head indicated previously. As a result, small and mass equipment were realizable.
[0025] Moreover, although the equipment which has one disk here was indicated, it is clear that the same effect is acquired also with equipment with the disk of two or more sheets.
[0026]
[Effect of the Invention] In the magnetoresistance-effect type element using the ferromagnetic tunnel effect, this invention uses the layered product of a ferromagnetic metal membrane / non-magnetic metal film / ferromagnetic me membrane for the fixed bed of a ferromagnetic tunnel effect film, is combining the ferromagnetic metal membrane o two sheets in antiferromagnetism, makes the substantial magnetic moment of the fixed bed small, and improves the bias profile of a free layer. By applying this element to the thin film magnetic head, vertical asymmetry was small an the regenerative signal with high linearity was obtained. Moreover, the small mass magnetic recorder and reproducin device with high recording density was realizable by carrying this thin film magnetic head.

[Translation done.]